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ABSTRACT

The purpose of the present study is to examine the effect of instruction based on constructivist approach on 9th grade students' understanding of chemical bonding concepts (n=41). Also, the effects of gender differences were investigated. Control group students were taught by traditional instruction. Experimental group students were instructed by instruction based on constructivist approach. All students were administered the Chemical Bonding Concept Test as a pre- and post-test. The analysis of the results indicated that there was a significant mean difference between two groups in terms of understanding chemical bonding concepts. However, no effect of gender difference on understanding of chemical bonding concepts was found. This study has implications that chemistry instruction should address development of scientific knowledge through consideration of students' existing ideas. (Author/KHR)

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# CONSTRUCTIVIST APPROACH: REMOVING MISCONCEPTIONS ABOUT CHEMICAL BONDING

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Abstract

The purpose of the present study is to examine the effect of instruction based on constructivist approach on 9th grade students' understanding of chemical bonding concepts. Also, the effects of gender difference was investigated. 41 9th grade students (23 females and 17 males) participate din the study. There were two groups of students as control group and experimental group. Control group students were taught by traditional instruction. Experimental group students were instructed by instruction based on constructivist approach. The two instructional methods were randomly assigned to the groups. All students were administered Chemical Bonding Concept Test as pre and post test. The analysis of the results indicated that there was a significant mean difference between two groups in terms of understanding of chemical bonding concepts. However, no effect of gender difference on understanding of chemical bonding concepts was found. This study has implication that chemistry instruction should address development of scientific knowledge through consideration of students' existing ideas.

Keywords: Chemical bonding, constructivist approach, misconception, chemistry education.

## Introduction

Recent research related to learning science has focused on students' preinstructional conceptions. According to Ausubel (1968), the most important single factor influencing learning is what the learner already knows. He proposed a theory of meaningful reception learning. This theory says that meaning occurs when learners actively interpreted their experiences using certain cognitive operations that cause learning. Cognitive structure of the learner determines how knowledge will be incorporated and describes how linkages will occur. Ausubel (1968) claimed that if the learner makes connection between what he already knows and new potentially meaningful information in a nonarbitrary and substantive way, then meaningful learning occurs. For meaningful learning to occur, there should be two conditions: new knowledge must have potential meaning, the learner must have relevant concepts to anchor the new ideas and the learner intends to incorporate the new knowledge in a nonarbitrary, nonverbatim way. When one or more of these requirements are not met, rote learning, verbatim memorization, occurs. In rote learning students do not develop hierarchical framework of successively more inclusive concepts instead they accumulate isolated propositions in their cognitive structure. This causes poor retention and retrieval of new knowledge to solve problems. Therefore, meaningful learning is preferred outcome in school situations. The main purpose of this study was to investigate the effect of instruction based on constructivist approach on students' understanding of chemical bonding concepts.

Ausubel's theory influenced research on instruction and students' preinstructional conceptions. Similarly, constructivist theory deals with students' preconceptions. From constructivist point of view, knowledge cannot be transferred into the students' mind, instead students construct their own meanings from the words or visual images they hear or see. Knowledge is not passively received from the teacher or through the senses. It is actively built up by the learner. Constructivism focuses on the way in which learners construct useful

knowledge. It may be through personally constructed or socially mediated. Learners form, elaborate and test new knowledge until they become satisfied. Knowledge develops and continues to change with the activity of the learner. Then, learning occurs by changing and organizing cognitive structure. Students create new meaning for scientific concepts by reflecting their mental activity. Cognitive reorganization takes place as learners try to overcome obstacles or contradictions during the activity they involved (Driscoll, 1994). Based on this perspective, teaching is not providing information and checking whether students have acquired it or not. Teaching is creating situations in which students are actively involved in scientific activities and they make their own construction. Teachers see students' constructions through students' sensorimotor and mental activities and communication. Teaching from constructivist theory aims at applicability of knowledge in situations. Students should build connections between daily life and their scientific conceptions. Also, according to this approach, students have to learn not only science content but also science principles and concepts. They should realize that science knowledge is a tentative human construction and not an eternal truth (Niedderer, 1987).

Constructivist teaching strategies take students' existing ideas as a starting point in instruction. Constructivist approach is student centered in that it uses subject matter for interactive engagement with students. Classroom climate encourages discussions and negotiation of ideas. This gives opportunity to students to revise their structure and see other students' ideas. Group discussions where students are encouraged in talking about tasks and sharing their ideas help them construct meaning. So, learning science involves having different way of thinking and explaining world and becoming socialized. In other words, learning science includes both personal and social processes (Driver et al., 1994). To investigate students' preinstructional conceptions many methods can be used such as naturalistic settings, interviews, conceptual relationships, diagnostic test items and

computerized diagnosis. There are many research studies investigating the effectiveness of constructivist strategies such as scientific inquiry (Carey, Evans, Honda, Jay & Unger, 1989), cognitive conflict (Niaz,1995) and process of consensus (Meyer & Woodruff, 1997).

Studies of students' conceptions indicated that students might explain particular situation differently from scientific explanation. These mistaken answers of students to a particular situation, their ideas that cause mistaken answers about a particular situation or their beliefs about how the world works different than that of the scientists are called as "misconception". If a student holds misconceptions, these misconceptions interfere with the subsequent learning. Therefore, new knowledge cannot be connected to his existing structure and misunderstanding of the concept occurs (Nakhleh, 1992). Thus, students' misconceptions should be identified and removed during the instruction. Conceptual change refers to changing one's conceptions by capturing new conceptions, restructuring or exchanging existing conceptions for new conceptions. Posner, Strike, Hewson and Gertzog (1982) proposed four conditions for conceptual change: 1. There must be *dissatisfaction* with existing conceptions. 2. A new conception must be *intelligible*. 3. A new conception must be *plausible*. 4. A new concept must be *fruitful*.

Chemical bonding is one of the basic topics in chemistry. Since it is an abstract concept that cannot be applied to everyday life directly, many students aren't able to comprehend this concept and they hold misconceptions (Boo, 1998; Peterson & Treagust, 1989; Tan & Treagust, 1999; Taber, 1997). Thus, students' misconceptions should be identified and new instruction methods focusing on students' misunderstanding should be developed.

In the light of this literature, this study compared the effectiveness of instruction based on constructivist approach (ICA) over traditionally designed chemistry instruction (TDCI) on

students' understanding of chemical bonding concepts. In addition, the effect of gender difference on understanding of chemical bonding concepts was investigated.

## Method

*Subjects of the Study*

This study consisted of 41 ninth grade students (17 male and 24 female) from two classes of a chemistry course taught by the same teacher. Two instruction methods used in the study were randomly assigned to groups.

*Instrument*

Chemical Bonding Concept Test (CBCT) developed by the researcher. The content was determined by examining textbooks, instructional objectives for the chemical bonding unit and related literature. Content validity was checked by experts in chemistry education, chemistry and by the course teachers. During the developmental stage of the test, the instructional objectives of chemical bonding unit were determined. The questions in the test were developed from the literature related to students' misconceptions with respect to chemical bonding and the set of pilot interviews with some classroom teachers. The test included two parts: First part consisted of two-tier questions and examined students' knowledge of chemical bonding. Each question in this part had two sections: a response section in which students were asked to mark only one of the two possible answers and a reason section in which students were asked to select the reason which explains the answer in the previous part of the question. Second part of the test consisted of multiple choice questions. Each question in this part had one correct answer and four distracters. Each distracter of an item reflected students' alternative conceptions or misconceptions found from related literature and pilot interviews with chemistry teachers. The reliability of the test was found to be 0,72. This test was given to students in both groups as a pre-test to control

students' understanding of chemical bonding concepts at the beginning of the instruction. It was also given to both groups as a post-test to compare the effects of two instructions (ICA & TDCI) on understanding of chemical bonding concepts

*Treatment*

This study was conducted over four- week period. The topics related to chemical bonding were covered as part of the regular classroom curriculum in the chemistry course. These topics were definition of the chemical bond, formation of bonds, types of bonds (intramolecular and intermolecular bonds), polarity and properties of ionic and covalent compounds.

There were two groups in the study: experimental group and control group. Both groups were instructed by the same teacher on the same content of chemistry course. At the beginning, both groups were administered CBCT to determine whether there was any difference between two groups with respect to understanding of chemical bonding prior to instruction.

In the control group, the teacher directed strategy represented the traditional approach used in the course. The students were instructed with traditionally designed chemistry texts. During the classroom instruction, the teacher used lecture and discussion methods to teach concepts. Also, the students in the control group were provided with the worksheets. Each worksheet consisted of one or two pages that included questions to be answered, tables to be completed or space for students to make sketches. The teacher roomed the room, acted as facilitator and answered some questions and make suggestions when needed. Worksheets were corrected and scored and the students investigated their sheets after correction.

The experimental group was instructed by using constructivist approach. At the beginning of the instruction, the teacher asked students some questions. Students were allowed to discuss these questions in groups by using their previous knowledge related to

atoms. During discussion in a group, they saw both their own and other's thinking, shared their ideas, defended their answers and reached a consensus about the question. These questions promoted student-student interaction and agreement before the teacher presented each concept. Meanwhile, the teacher didn't interfere with the students. They constructed their tentative answers freely. Each group gave a common answer to the teacher after discussion. In this way, the teacher had opportunity to view students' previous ideas. Based on their answers, he explained the concepts. While explaining the concept, he emphasized on students' misconceptions and why they were wrong. He presented scientifically correct explanation by using analogies and examples. Since chemical bonding is an abstract topic, he tried to give examples from daily life as much as possible. He used analogies to enhance understanding.

At the end of the treatment, all students were given Chemical Bonding Concept Test as a post-test.

## Results

The data obtained from concept test were analyzed by using SPSS (Statistical Package for Social Sciences) (Norusis, 1991). In order to identify the relative performances of the students' previous learning in chemical bonding concept before the treatment, all of the subjects were administered CBCT as a pre-test. The results showed that there was no significant difference between the ICA group and the TDCI group in terms of chemical bonding concept achievement ($F=1.242$, $p=0.272$).

To test that there is no significance difference between the post-test mean scores of the students taught by ICA and those taught by TDCI with respect to achievement related to chemical bonding concepts, analysis of variance (ANOVA) was used. The result revealed that there was a significant difference between the post-test mean scores of the students taught by

ICA and those taught by TDCI with respect to the achievement related to chemical bonding concepts ($F=5.147$; $df=1$; $p<0.05$). The ICA group scored significantly higher than TDCI group ($X$ (ICA) = 9.29, $X$ (TDCI) = 7.11). On the other hand, there was no significant effect of gender difference on achievement ($F=0.081$; $df=1$; $p>0.05$; $X$(female)=8.34; $X$(male)=8.06).

## Discussion

The main purpose of this study was to compare effectiveness of the instruction based on constructivist approach and traditionally designed chemistry instruction on 9$^{th}$ grade students' understanding of chemical bonding concepts.

In the light of the result obtained by analyses, it may be concluded that the constructivist approach caused a significantly better acquisition of scientific conceptions and elimination of alternative conceptions than the traditionally designed instruction. This finding supports the findings of Meyer and Woodruff (1997), Niaz, 1995 and Dekkers and Thijs (1998) that constructivist strategies were more effective when compared to other alternative teaching methods.

In this study, asking questions before presenting new concepts caused learners to activate their relevant knowledge. They used their prior knowledge to answer teacher's questions. They tried to handle questions on their own first, and then teacher's explanations helped them construct scientifically acceptable concepts. The aim was to make students aware of their ideas and thinking process as well as other students' ideas. Also, the teacher had opportunity to view students' conceptions prior to instruction and designed the flow of the lesson on the basis of students' answers. Interaction between students-teacher and among students helped construction of knowledge in a meaningful way. Since chemical bonding is an abstract topic, the teacher used analogies in order to make concepts clear. On the other hand, students in control group did not have opportunity to realize their conceptions and think about

the situations. There was a slight interaction between the teacher and students and among students. This might be a reason why control group students continued to hold misconceptions in their cognitive frameworks. More meaningful learning occurs if students are asked to think about appropriate questions for a given situation and explain relationships.

Teachers have great control what they teach but less control over what students learn. Constructivist approach gives priority not to teach the same concepts to all students but to carefully analyze students' understanding to increase learning. Constructivist teachers consider what students think about concepts and formulate lessons and plan instruction on the basis of students' needs and interests. They structure lessons in order to develop students' higher order abilities such as critical thinking, mindful consideration and reflection, problem solving and active use of knowledge and skills (Brooks and Brooks, 1999).

Chemical bonding is a very abstract topic. Therefore, students have difficulty in understanding the concepts related to chemical bonding. For example, students couldn't understand the nature of bonding. Most students think that bonds are simple connections rather than forces. In addition, they hold another misconception that a bond should be either ionic or covalent. So when teaching of chemical bonding concepts, the teachers should make the concepts concrete as much as possible. It is not enough that students became aware of their existing ideas, also they should change their wrong views through interaction with their teacher and the students. The students should apply their experience to the new situations. The teachers should create learning environments where students can use their prior knowledge in solving problems. For instance, the students' knowledge about the structure of an atom helps them understand why atoms bond to each other. This also favors conceptual change. Students realizing that their current ideas are not effective in explaining the situation take the new knowledge into account seriously. The teacher may use various activities such as analogy, concept maps or cognitive conflict for conceptual change.

This study suggests that teaching strategies should be based on students' ideas and students should connect their thinking and experiences with the scientific concepts. Curriculum should address development of scientific knowledge through consideration of students' existing ideas. Teachers should create a learning environment where students can negotiate and question their own and others' ideas. They should offer students constructivist strategies that help them leave rote memorization.

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